

CLAIMS

1. Device for determining an angle of rotation $\Delta\varphi$ between two shafts, especially between a camshaft (5) and the crankshaft of an internal combustion engine, which has a camshaft regulator with an electronic regulator and means for determining the angle of rotation position of the camshaft (5) and the crankshaft, characterized in that a crankshaft trigger wheel with reference and trigger marks is fixed to the crankshaft for determining the angle of rotation position of the crankshaft and an electromechanical camshaft regulator is provided, which has a triple-shaft gearbox (1), having a first shaft (3) that is locked in rotation with the camshaft (5), a second shaft (4) that is connected via a camshaft driving wheel (7) to the crankshaft, and a third shaft as a regulating shaft (6) that is connected to a permanent magnet rotor (8) of a BLDC motor (2), wherein the BLDC motor (2) has a housing-fixed stator (9) with preferably three phases and an electronic commutation, which is controlled through commutation signals, which are used simultaneously for determining the angle of rotation position of the camshaft (5) and together with signals of the crankshaft trigger wheel for calculating an angle of rotation $\Delta\varphi$ between camshaft (5) and crankshaft.

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2. Device according to claim 1, characterized in that the crankshaft trigger wheel is formed as a ring gear or resolver and the commutation signals can be generated by Hall sensors or reluctance sensors, through optical, inductive, or capacitive sensors, or without sensors through self-induction in the phases of the stator (9).

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3. Device according to claim 2, characterized in that the sensors can be installed in components of the BLDC motor (2), which rotate at the rotor rpm, such as, e.g., support or sealing rings.

5 4. Device according to claim 3, characterized in that a RAM or an EPROM are provided in a controller or an active, memory-equipped Hall sensor, which store or make detectable counts and thus a position of the camshaft (5) in standstill or during startup of the internal combustion engine.

10 5. Method for determining the angle of rotation $\Delta\phi$ between a camshaft (5) and the crankshaft of an internal combustion engine, especially using the features of the independent device claim 1, characterized in that the angle of rotation $\Delta\phi$ is calculated through additive and multiplicative links of commutation and trigger wheel signals.

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6. Method according to claim 5, characterized in that a count-based calculation of the angle of rotation $\Delta\phi$ involves, under use of the commutation signals of Hall sensors, the following relationship:

$$\Delta\phi = \left[\left(\text{Number}_{\text{Reference mark}} + \frac{\text{Number}_{\text{Trigger}}}{\text{Total}_{\text{Trigger}}} \right) \times \frac{1}{2} - \frac{\text{Number}_{\text{Hall signal}}}{\text{Number}_{\text{Magnet pole}}} \right] \times \frac{360^\circ}{i}$$

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7. Method according to claim 6, characterized in that the trigger mark signals detected after passing a reference mark are deleted after reaching a next reference mark.

8. Method according to claim 7, characterized in that a change in rotation direction of the BLDC motor (2) is determined by evaluating a resulting change in the commutation signals, whereby these are differentiated.

5 9. Method according to claim 8, characterized in that the differential of the commutation signals of one of the three Hall sensors is combined with the status (High/Low) of the differential of the two other commutation signals.

10 10. Method according to claim 5, characterized in that a time-based calculation of the angle of rotation $\Delta\phi$ involves the following relationship:

$$\Delta\phi = \int \frac{(n_{kw} \div 2 - n_{vw})}{i} \times dt, \text{ where}$$

n_{kw} = crankshaft rpm;

15 n_{vw} = rpm of the BLDC motor (2) and

i = gear transmission ratio between the regulator shaft (6) and the camshaft (5) for a stationary driving wheel (7).

20 11. Method according to claim 9, characterized in that the count-based and time-based determination of the angle of rotation $\Delta\phi$ can be combined.

25 12. Method according to claim 10, characterized in that the camshaft (5) assumes a reference position, for example, a base position with a mechanical stop, for the count-based and time-based determination of the angle of rotation $\Delta\phi$ at regular intervals, in order to zero the counts.

13. Method according to claim 10, characterized in that for a whole-number ratio of the crankshaft and camshaft signals, a phase position of the camshaft relative to the crankshaft is determined by evaluating a difference of the signals in a position regulator, which preferably works with a locked
5 camshaft or crankshaft rpm.

14. Method according to claim 11, characterized in that the camshaft (5) can be adjusted into any desired position after the ignition is turned off and when the internal combustion engine stops through after-running of a BLDC
10 motor (2) or through after-running of a controller.